THE EFFECTS OF DIFFERENTIAL OUTCOMES ON AUDIO-VISUAL CONDITIONAL DISCRIMINATIONS IN CHILDREN WITH ASD

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The differential outcomes effect (DOE) refers to an observed increase in rates of acquisition of simple or conditional relations when the contingencies of reinforcement arrange for reinforcers to be uniquely correlated with a particular stimulus or response relative to conditions where the reinforcers are not uniquely correlated with either stimulus or response. This effect has been robustly documented in the literature with nonhuman subjects. This study asked whether the DOE would be observed with children with autism spectrum disorder (ASD) learning audio-visual conditional relations. Two participants learned two sets of 3 audio-visual conditional relations. For one set, the training conditions arranged for each of the three conditional relations to be uniquely correlated with a particular reinforcing stimulus (the DO condition). For the second set, the training conditions arranged for the same reinforcer to be used for all three audio-visual conditional relations (the NDO condition). Early results show that audio-visual conditional relations were acquired faster under the DO condition relative to the NDO outcomes condition (accuracy in DO condition was 30.8% higher on average than in NDO condition). These data suggest that differential outcomes should be more thoroughly investigated with children with diagnoses of ASD.

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THE EFFECTS OF DIFFERENTIAL OUTCOMES ON AUDIO-VISUAL CONDITIONAL DISCRIMINATIONS IN CHILDREN WITH ASD

Introduction

The differential outcomes effect (DOE) refers to an observed facilitation of simple or conditional discrimination performances when each discriminative stimulus-response sequence produces different reinforcers relative to conditions in which each discriminative stimulus-response sequence produces the same reinforcer. Under a differential outcomes procedure, for example, touching the picture of a dog (and not cat) upon hearing “dog” might result in chocolate, while touching the picture of a cat (and not dog) upon hearing “cat” might result in a cracker.

In the basic literature, DOE has been widely demonstrated across a wide range of conditions, species, and tasks since the 1970s (Friedrich et al., 2011; Kelly & Grant, 2001; Trapold, 1970; Overmier, Bull, & Trapold, 1971; Miller et al., 2009; Miyashita, Nakajima, & Imada, 2000; Sherburne et al, 1998; Urcuioli, 1991). Tasks used range from simple two-choice and go/no-go successive discriminations (e.g., Fedorchak & Bolles, 1986; Friedman & Carlson, 1973; Morgan & Baker, 1997; Urcuioli & Zentall, 1992) to more complex discriminations (Nakajima & Kobayashi, 2000) and identity and symbolic matching-to-sample (e.g., Alling, Nickel, & Poling, 1991a, 1991b; Urcuioli & DeMarse, 1996; Zentall & Sherburne, 1994).

The DOE has also been studied and consistently demonstrated when the changes involve not only the reinforcers themselves, but also in the context of reinforcement. For example, in addition to different reinforcers, changes in the context of reinforcement such as presence or absence of chamber lights, positions of feeders, and accompanying auditory stimuli have also been shown to produce the DOE (Chatlosh and Wasserman 1992; Freidrich & Zentall, 2011; Kelly & Grant, 2001; Miller et al., 2009). Similar results have been reported using differential delays to reinforcement (Carlson & Wielkiewicz, 1972), differential magnitudes of reinforcement (Carlson & Wielkiewicz, 1976), and differential probability of the same reinforcer (DeMarse & Urcuioli, 1993; Urcuioli, 1990).

Trapold (1970), for example, compared the rate with which rats learned a complex auditory conditional discrimination with and without differential outcomes. Rats learned to press the left or right lever under control of auditory stimuli. For one group, correct responses produced food on trials with one discriminative stimulus and liquid sucrose on trials with the other discriminative stimulus. This group learned to perform the correct spatial responses more rapidly than the control group for which the same outcome occurred on all reinforced trials.

In a study by Miyashita, Nakajima, and Imada (2000), three horses learned a discrimination task in which the color of a center panel signaled either a left or right lever press. Discrimination performance was better when the combinations were differentially reinforced by two types of food (chopped carrot pieces and a solid food pellet) than when the combinations were randomly reinforced by these outcomes or when there was a common reinforcer for each of the correct combinations.

Miller, Freidrich, Narkavic, and Zentall (2009) trained pigeons on a delayed matching-to-sample task in which choice of the correct comparison stimulus resulted in illumination of one of two houselights. For one group of pigeons, the color of the houselights that followed each correct comparison choice was correlated with the color of the correct comparison. For another group, one of the two houselights was randomly lit following each correct response to either comparison stimulus. Significantly more accurate performance was obtained at greater delays when differently colored houselights were correlated with the comparison stimuli relative to when they were not.

The DOE has been demonstrated with many different nonhuman species working in a wide variety of preparations and tasks with a large array of outcomes in a literature base that spans over 40 years. Over the same time period, there has been a small but persistent interest in the DOE with human participants in applied contexts. One of the first to suggest a possible positive effect of differential outcomes procedures on human learning was Shepp (1962, 1964). Studies followed that explored the acquisition of two-choice conditional discriminations and demonstrated the DOE in children with autism spectrum disorder (ASD) (Litt & Schriebman, 1981) and in both children and adults with developmental disabilities (Malanga & Poling, 1992; Saunders and Sailor 1979; Shepp, 1962).

In 2001, Estevez et al. conducted a study examining the efficacy of a differential outcomes procedure with typically developing children between 4 and 8 years old. The effect was studied in two experiments in which performance on a conditional discrimination task was compared under conditions of differential and non-differential outcomes. In Experiment 1, children from 4 years to 7 years learned faster and showed higher terminal accuracy when differential outcomes were arranged. At first, they did not find the same results for the older participants (the 8 year olds). They hypothesized that this was because the tasks were too simple. Thus, in Experiment 2, they increased the difficulty of the task and observed the DOE with the 8 year olds as well.

Chong and Carr (2010) evaluated a differential outcomes procedure during discrimination training with three children with autism spectrum disorder (ASD). During the differential outcomes condition, correct responses to target exemplars resulted in one of three specific food reinforcers being delivered (i.e., each exemplar was assigned a specific food reinforcer). During the non-differential procedure condition, correct responses to exemplars produced, in a semi-random order, 1 of 3 food reinforcers equally and non-differentially (i.e., same food reinforcers as in DO condition). Use of response-specific reinforcers did not produce large or consistent improvements in training efficiency compared to the non-differential procedure.

A more recent article by McCormack, Arnold-Saritepe, and Elliffe (2017) reported the use of a differential outcomes procedure to teach novel tacts of instrument sounds to children with ASD. For one set of instruments, response-specific reinforcers were used in combination with social reinforcement. For the other set, reinforcers were provided non-differentially. Two out of three participants showed enhanced learning in the differential outcomes condition.

Taken together, these studies show that, although the DOE has been observed with human subjects, the phenomenon has not been documented with the same frequency, consistency, or rigor as in the nonhuman laboratories (Chong & Carr, 2010; Litt & Schreibmen, 1981; Malanga & Poling, 1992). Most of the studies with human subjects have used group comparison designs which make it difficult to isolate precisely the conditions under which DOE may be optimally observed for individual subjects. As an example, Estevez et al. (2001) and others have found that DOE is most likely seen above some threshold level of difficulty. Since group designs do not allow task characteristics to be adjusted individually, effects related to response requirements may be masked. Further research is needed to examine the conditions under which the DOE is demonstrable with humans and to develop clinically practical ways to use differential outcomes to improve the learning rates of children with ASD.

In the current study, we investigated the DOE in children with ASD using differential outcomes procedures for audio-visual conditional discrimination tasks with individualized and clinically relevant targets. Tasks were selected based on the individual skill levels of the participants. To avoid a ceiling effect that could occur with relatively simple tasks and that would not allow differentiation between conditions, task difficulty was controlled. Selection of reinforcers was designed to control for overall preferences, ensure that the procedures did not favor differential outcomes procedures, and balance preferences across conditions and targets.

Method

General Procedure and Flow

The study compared the effects of differential and non-differential outcomes using a within-subject experimental design. Two children learned six audio-visual conditional discriminations; three in which the stimuli presented as consequences for correct responding were uniquely correlated with sample stimuli (hereafter, differential outcomes or DO) and three in which they were not (hereafter, non-differential outcomes or NDO). The children were exposed to DO and NDO conditional discrimination teaching sessions daily in sessions separated by at least 1.5 hours in an adaptation of an alternating treatment design (Sindelar, Rosenberg, & Wilson, 1985). Finally, all phases (within and across participant) were conducted individually in a non-concurrent multiple baseline design.

Participants and Setting

Two individuals were recruited from a local autism services clinic. Sally was a 3-year-old girl diagnosed with ASD, who had been at the clinic for six months and had a limited listener repertoire (she scored low on the VB-MAPP listener skills level 1 milestones, had recently acquired receptive identification (ID) of 15 preferred items, and had just begun audio-visual conditional discrimination training with common household items, such as dishes and furniture). This was the totality of audio-visual conditional discriminations she had acquired. Jack was a 6-year-old boy diagnosed with ASD, who had been at the clinic for two years, and had a fairly advanced listener repertoire (VB-MAPP scores were between Level 2-3). He had acquired a large repertoire of receptive ID tasks (over 200 targets), was able to sort by some features (e.g. color and shape), and was beginning to learn receptive ID of items based on function (e.g. “which one do you cook with?”). Both participants could follow simple one step instructions, had low levels of challenging behavior and noncompliance, and were able to work at a table for at least five minutes at a time.

Teaching sessions were conducted in a treatment room at the day clinic from which participants were recruited. Sessions occurred four days per week (with the exception of absence of participants due to illness) with two sessions scheduled per day. During these daily sessions, two teaching conditions (described below) were implemented with 1.5-2 hour intervals between sessions. All data reported in this study were collected during table-top tasks in which the researcher and the participant sat diagonally from each other at a small table. All materials (stimuli and consequences) used during the training were placed in a container next to the researcher, out of view of the child.

Data Collection and Inter-Observer Agreement (IOA)

Paper and pen data was collected for the preference assessments, and for accuracy during probe and teaching sessions. A second observer collected data for IOA within session. Partial agreement within trial (trial-by-trial IOA) was evaluated during 38% of total sessions.

Preference Assessment

A brief multiple-stimulus-without-replacement (MSWO) preference assessment was conducted to identify preferred items from which differential and non-differential outcomes were selected (DeLeon & Iwata, 1996). Based on informal observation of the participants, ten items were selected that were different topographically and functionally from each other (e.g. book, Barbie doll, toy phone, pop-up toy). The items were randomly placed on a table without regard to position or orientation for each session. Participants were instructed to "pick one", and when they selected an item, they were given access to that item for 30 seconds, after which the item was not returned to the array. Participants were directed back to the table and instructed to pick again. This was continued until all items had been selected.

MSWO sessions were run until a stable rank-order among the items was established (i.e. differentiation was seen between relative value of items). This took an average of six sessions. Rank was established by assigning values to order of selection (1^{st} selection = 10 pts, 2^{nd} = 9 pts, etc.). Once the ranking was complete, four items with the highest ranks (or points) were selected for use in sessions. With one exception (Sally, Set B), the item with the highest preference rank was selected as the non-differential (common) outcome and the next three highest ranking items were used as consequences in the differential outcomes condition. Access to these items was then restricted to research sessions (i.e. they were removed from use in usual day-to-day sessions) until the respective conditions were complete. MSWO preference assessments were conducted twice for Sally, prior to introducing Sets A and B (see Figure 6), and again prior to introducing Sets C and D (see Figure 7). The assessment was conducted once for Jack (see Figure 8).

Task Selection

Tasks were individualized based on the current skill set of the participants. An audio-visual conditional discrimination task was selected for Sally as she had been successful with these types of tasks in the past, but did not yet have an extensive repertoire. Sorting by category was selected for Jack as he had a long history with audio-visual conditional discrimination tasks, acquired new receptive ID targets rapidly, and had demonstrated some success with sorting tasks. For Jack, two different tasks were introduced and discontinued before selecting a complex audio-visual conditional discrimination task in the form of sorting by category. The first task was an audio-visual conditional discrimination task similar to that chosen for Sally. Jack acquired this task by the end of the first session, responding with 100% accuracy to all stimuli after one initial prompt to each. Given the apparent role of task difficulty and its relation to observation of the DOE (Estevez et al., 2001), those targets were discontinued, and a new task was probed. The second task was an audio-visual conditional discrimination similar to the first task, but the instructions were more complex (e.g. pick the one that helps children cross the street safely). Jack also acquired this task by the end of the first session with 100% accuracy. The next task probed was sorting by categories, which was ultimately selected. For this task, Jack was required to flip through a stack of nine cards, three of which were target stimuli, placing the target stimuli together in one pile, and the distractors in a separate pile.

Target Selection

Potential targets were chosen from on a list of clinically relevant goals identified for each participant based on their individual VB-MAPP assessments and treatment plan goals. All materials were novel to each participant (i.e., children had no prior exposure to attempts to teach these targets). The selection of particular targets was based on initial probes conducted without reinforcement or error correction to identify pre-existing auditory visual conditional relations in the child's repertoire. The child was praised for "working hard" and "trying" and previously mastered tasks (e.g., motor imitation, simple 1-step instructions, etc.) were alternated with the conditional discrimination tasks being probed. Correct responses to previously mastered tasks were followed by reinforcers and praise. Incorrect responses to previously mastered tasks were followed by a prompt. Targets were selected for inclusion in the study if the participants made no correct responses during target selection probes.

For Sally, one 3.5x5 inch picture card was made for each target. To probe, she was instructed to select the correct picture from an array of three cards (e.g. "touch hippo"). After each response, the cards were removed, randomly rotated, and a new array was presented. Following a correct response, the card was removed from the bank. Each target was probed three times. Following an incorrect response, no attempted response after 5 seconds, or the participant responding with "I don't know" or some equivalent, the card remained in the bank. Twelve targets (to compose four sets) were selected for Sally, shown in Table 1.

For Jack, each target consisted of three stimuli, also 3.5x5 inch picture cards, belonging to the same category (e.g. people, animals, blocks). To probe, he was given a stack of three categories (9 cards) and told to find all the cards from a specific category (e.g. "find all the shapes"). After each response, the cards were removed, different categories were selected, and the stack was reshuffled. Following a correct response, successful sorting of the three cards belonging to the specified category, that category was removed from the bank. Each category was assessed three times. Six categories (to compose two sets) were selected for Jack, shown in Table 2.

Teaching Procedures

For Sally, each trial began with three picture cards placed in an array on the table in front of her. She was given the instruction to touch a specific card (i.e. "touch hippo"). Semi-randomly rotating among targets (the same target would not be presented more than twice in a row),

Initially, an immediate gestural prompt was provided for all targets. Three correct responses following prompts led to an increase of prompt-delay to 2 seconds. The delay was increased to 5 seconds following three correct independent responses, and decreased following two incorrect responses following the same intervals (Charlop, Schreibman, & Thibodeau, 1985). A correct response for Sally was defined as touching the instructor-specified picture card independently. Incorrect responses were followed by immediate removal of all cards, a 5-second pause, and representation of the identical array (i.e. cards in the same position as when the error occurred) with a gestural prompt. Correct responses to the error correction prompt was followed by delivery of the reinforcer, and continuing with randomization of trials. An incorrect response following a gestural prompt would be followed by a physical prompt. No such errors occurred for Sally.

During the differential outcomes condition, correct responses (both prompted and independent) were followed by delivery of a correlated preferred item for 10 seconds. For example, correct selection of hippo was always followed by access to the Barbie. During the non-differential outcomes condition, a single common reinforcer was used for all three targets. Praise was not provided for correct responses in either condition, but was provided for playing nicely, sitting nicely in the chair, working hard, etc. during the inter-trial interval.

For Jack, two 5x7 colored cards were placed on the table and he was handed a stack of the nine picture cards assigned to the respective condition. Semi-randomly rotating among targets (i.e., a single category was not presented more than twice in a row) he was instructed to place the specified category onto the green cards (i.e., “put all the vehicles on the green card”). A correct independent response for Jack was defined as placing all three cards for the specified category onto the green card, and placing all other cards onto the orange card. The prompting procedure used for Jack was identical to that used with Sally. Incorrect responses were followed by the same error correction procedure used with Sally. Correct responses to the error correction prompt led to continuing with randomization of trials, and an incorrect response following a gestural prompt would be followed by a physical prompt. No such errors occurred for Jack.

In the differential outcomes condition, correct responses (both prompted and independent) were followed by delivery of the correlated preferred item for 10 seconds. For example, correctly sorting the category “blocks” was always followed by delivery of the book. In the non-differential outcomes condition, a single common item was delivered for 10 seconds following correct responses. Praise was not provided for correct responses in either condition, but was provided for playing nicely, sitting nicely in the chair, working hard, etc. during each inter-trial interval in both conditions.

For both participants, training with both sets of targets was conducted in their respective conditions, differential or non-differential, until accuracy scores differentiated by 20% for at least three days across conditions and/or until a decrease in performance was observed in one of the conditions, at which point the targets assigned to the condition in which performance was lower were taught using the more effective procedure. If no significant differentiation between conditions was seen, the task was reevaluated. Mastery criterion for individual targets was at least 80% accuracy across three sessions. Sessions were run until all targets in both sets were mastered.

Ten trials with each target were conducted during each session, totaling thirty trials per session. Sally was given a short break (approximately 2 minutes) after fifteen trials had been run, as she was not yet able to calmly work at the table for more than 5 minutes continuously. Jack completed the thirty trials with no breaks except for 10-second intervals of access to preferred items.

Maintenance

After targets were mastered, they entered the maintenance phase. During maintenance, the clinic’s standard procedures were implemented for both participants. For example, the DO procedure was discontinued and the reinforcement schedule returned to the typical clinic schedule (VR-3) for each participant. Error correction returned to the standard procedures used at the clinic. Research targets were interspersed with other mastered targets such as gross motor imitation, simple instructions, etc. Data were collected across three trials per target. Maintenance probes were conducted 1-2 times per week with each participant.

Generality Probe

After mastery, probes were conducted to assess generalization of the trained relations to novel targets. For Sally, two additional exemplars of each target were made and for Jack, he was instructed to sort the same categories of picture cards composed of novel stimuli (e.g. three new stimuli for the “people” category). Probes were conducted using the same procedures as material probes. Generality probes were interspersed into the maintenance trials, with no reinforcer or error correction following any responses to the new exemplars. Three trials with each new target were conducted.

Results

Results for both Jack and Sally showed DOE, with more accurate responding seen in the DO condition relative to the NDO condition for both participants. Rapid increases in accuracy were seen when the targets originally introduced in the NDO condition were switched to the DO condition.

Sally

Sally showed an increase from baseline in the first teaching session in both the DO and the NDO conditions, with Set A (DO) slightly elevated relative to Set B (NDO) (40% and 27% respectively). In following sessions, scores for Set A (DO) increased to an average of 69% across four sessions while Set B (NDO) remained lower at an average of 34% across four sessions. Given the clear differentiation, DO procedures were implemented with Set B after session X. Accuracy improved almost immediately and increased consistently throughout this condition; Sally mastered all three targets within six DO sessions. Both sets were learned to mastery within eleven sessions. These results are shown in Figure 4.

With the second pair of targets for Sally, she emitted one correct response to one of the targets in the baseline probes. However, this only occurred once across the five probe sessions with Set C (fifteen trials of that specific stimulus, forty-five trials total). When teaching began, there was an immediate increase relative to baseline and clear differentiation between Set C (DO) and Set D (NDO) (40% and 21% respectively). Continuing increases in accuracy were observed with both Set C and Set D, but differentiation remained at more than 20% between conditions, so DO procedures were implemented with Set D following session X. Both sets were learned to mastery within ten sessions. These results are shown in Figure 5.

Jack

Jack’s accuracy scores did not show immediate improvements relative to baseline in either the DO or the NDO conditions (7% improvement in accuracy with Set A (DO) and 2% accuracy with Set B (NDO) during the first intervention sessions). However, in the subsequent sessions, a consistent increase in accuracy was seen for Set A (increasing to 86% by the fourth session), whereas continual improvement was not evident for Set B (initially increasing to 23%, but then decreasing to 11% by the fourth session). An immediate increase was seen in accuracy for Set B when DO procedures were implemented during session 16 (from 11% to 53%). Both sets were learned to mastery within eight sessions. These results are shown in Figure 6.

Maintenance

After the clinic's general procedures were put back in place, Sally's performance maintained at high levels (Figure 4 and Figure 5). She maintained an average accuracy of 93% across eight sessions, for Sets A and B (94.5% and 91.8% respectively), and an average accuracy of 97.8% across six sessions for Sets C and D (99% and 96.7% respectively). Jack maintained an average accuracy of 97.5% for Sets A and B, 98% and 97% respectively, across eight sessions. These results are shown in Figure 6.

Generality Probes

Generality probes were conducted using the same procedures used to select the original materials: three trials were conducted with each stimulus, no reinforcement was provided for correct responding, no prompting occurred, and no error correction was conducted.

For Sally, two new exemplars per target were probed. She responded with high accuracy for both Set A and Set B (89% and 94% respectively) as well as for Set C and Set D (100% and 89%).

For Jack, new sets of materials for the same categories were probed. Jack performed well when new exemplars were probed. His accuracy was high with both Set A and Set B (100% and 96% respectively) across the six categories.

IOA

Trial-by-trial IOA was calculated for each session using partial agreement within trial and averaged across sessions. IOA was collected within session by a secondary observer. For Sally, IOA was collected for 38% of total sessions (36% of sessions for Set A and B, and 40% of sessions for Set C and D) with 100% agreement. For Jack, IOA was collected for 38% of total sessions, with 93% agreement (a range of 83% to 100%).

Discussion

This study evaluated if the DOE could be demonstrated in two children with ASD using clinically relevant and individualized audio-visual conditional discrimination tasks. The DOE was demonstrated with both participants, and replicated using a second set of materials with one of the participants. These results add to the research base demonstrating the robust nature of the DOE and suggest the clinical utility of differential outcomes procedures. The rapid increases in accuracy and differential learning relative to standard reinforcement procedures shown in the current study suggest that DOE should continue to be studied and evaluated for use in practice.

The use of differential outcomes appears to show improved efficiency relative to non-differential outcomes. For Sally, it took eleven 10-12 minute sessions to acquire three new conditional discriminations introduced using DO procedures (Set A), totaling 120 minutes, 240 minutes for all six (Set A and Set C). Previously, Sally required six weeks of two sessions daily to learn the same number of targets. Assuming that the sessions lasted approximately the same time, over 600 minutes of instruction was required to teach six new targets. For Jack, his sessions lasted longer as his task was more time-consuming. His sessions lasted between 20-30 minutes and he mastered all categories in eight sessions, meaning he mastered six targets in approximately 400 minutes. He has taken four weeks to master six novel tasks in the past, and again assuming that the length of his sessions was fairly equivalent to that of the research sessions, 1,000 minutes of session time was needed to master these tasks. Time is a precious resource considering the amount of learning that is required to minimize the deficits seen in children with ASD during early intensive behavioral intervention (EIBI).

The fact remains that the DOE has not been consistently demonstrated in humans. For example, Chong and Carr (2010) published a failure to demonstrate the DOE. A possible account for the disparity in results between our study and that of Chong and Carr (2010) is the specific focus given to task difficulty in our preparation. There is evidence in the nonhuman literature that the DOE becomes more pronounced tasks increase in difficulty. This is most likely due to the presence of a ceiling effect when participants exhibit high levels of accuracy regardless of experimental conditions. This ceiling effect was seen very quickly with the first two tasks probed for Jack, and would not have allowed for differentiation between DO and NDO conditions.

Based on the current study alone, we are limited in our ability to attribute the outcomes directly to the DO procedures as we compared the use three correlated outcomes to use of a single common outcome as opposed to using three uncorrelated versus three correlated outcomes. This decision was made to ensure the integrity of the preparation and increase simplicity of this early step in DOE research with humans. However, there has been extensive nonhuman research into whether the effects are due simply to varied (uncorrelated) reinforcement or the specific correlation. Preparations have compared common, uncorrelated, and correlated outcomes, and the results clearly demonstrate that the key to the DOE is the correlation between response and outcome. Thus, we encourage further research with humans to extend our experimental question to correlated versus uncorrelated outcomes. We are also limited by the number of participants included in this study. The DOE has been unreliable with humans, and replication across more individuals would increase the confidence in our results.

Another limitation of the current study is that in the NDO condition, Jack and Sally were exposed to the common reinforcer thirty times per session, while in the DO condition each item was presented only ten times each per session. Increased exposure to the common reinforcer could result in satiation, suppressing learning in the NDO condition. This is why we controlled for preferences and used more highly preferred items in the NDO condition (Jack, Set B; Sally, Set D). Neither Jack nor Sally showed signs of satiation during sessions (i.e. pushing the item away, ceasing to interact with it, saying no, decrease in responding, etc.). In addition, the research done comparing different magnitudes of the same reinforcer correlated with specific responses still produced the DOE.

A single person, the researcher, conducted all preparations (MSWO preference assessments, task selection, and target selection probes), teaching, maintenance sessions, and generality probes. Thus, it is not clear if the results obtained in the current investigation would be replicated across other teachers implementing the procedures, though generality across stimuli was demonstrated. The effort required to set up the differential outcomes procedures, as well as the skill level of the teachers or therapists implementing the procedures, would need to be taken into consideration when extending the current procedures to clinical use. Replications across implementers, as well as investigations of feasibility and treatment integrity could further inform the clinical utility of DO.

Future research should replicate the evaluations of correlated outcomes versus uncorrelated outcomes that have been conducted in the basic literature with nonhumans. Research should also be done on what types of outcomes can be used to demonstrate the DOE. For example, there may be advantages to using stimulus changes, rather than different reinforcers, to produce the DOE in clinical practice. The nonhuman research has shown that changes in environment, position of reinforcement delivery, auditory cues, differential delays, differential magnitude, and differential probability have all been used to produce the DOE (Carlson & Wielkiewicz, 1972; Carlson & Wielkiewicz, 1976; Chatlosh and Wasserman 1992; DeMarse & Urcuioli, 1993; Freidrich & Zentall, 2011; Kelly & Grant, 2001; Miller et al., 2009; Urcuioli, 1990). These results demonstrate that a uniquely correlated reinforcer may not be necessary, and rather that presentation of neutral but differentially correlated stimuli along with a common reinforcer may be sufficient to produce the DOE with nonhumans.

A Word on the Theory

Traditionally, the DOE has been accounted for by outcome expectancy theory, which suggests that the anticipation of different response-contingent reinforcers acquires a discriminative function that supplements the stimulus control exerted by the programmed stimuli. This explanation considers the reinforcer to be an integral part of the learning that occurs in discrimination training, providing another source of stimulus control for responding (Urcuioli, 2005). Using ‘outcome expectancies’ as an explanatory mechanism for the DOE is problematic from a behavior analytic perspective. The framework either requires an assumption of control by stimuli that will be presented in the future or it relies on a currently acting state or condition called “anticipation” (of the reward) which can neither be controlled nor independently verified.

An alternative account, which may be slightly more straightforward from a behavior analytic perspective, is that of Sidman’s (1994/2000) theory of equivalence. Briefly, Sidman’s theory suggests that: 1) all positive elements of a contingency of reinforcement become equivalent, and 2) elements common across contingencies can cause these contingencies to merge; and 3) when the merger creates ineffective contingencies, the common elements are forced to drop out of the equivalence relation. Although not articulated by Sidman, the theory has implications for understanding the DOE. The use of a common reinforcer, as is typically programmed, might lead to the merger of what should be two separate equivalence classes of stimuli, responses, and reinforcers. The merger causes the contingencies to become ineffective (i.e., Sd1 and Resp2 in the same, merged, class) which forces the common reinforcer to drop out from the class to allow contingencies to work as programmed. The mechanisms proposed in the theory suggest that differential outcomes procedures might circumvent the merger-ineffective contingency-drop out -effective contingency process by using contingency-correlated outcomes that preclude class merger resulting in quicker acquisition of responding. Though interesting and important, testing or verification of these theories was not the focus of the work presented here.

In conclusion, a focus of behavior analytic treatment is to minimize deficits and teach socially relevant skills. Children with ASD who are falling behind even their peers with ASD cause even more concern. Differential outcomes procedures have produced significant increases in the speed at which skills are acquired as well as the accuracy of performances, suggesting that differential outcomes procedures could have clinical utility as a strategy to steepen the slope of developmental trajectories with individuals with ASD. The results of the current study showed that accuracy was higher and acquisition occurred more rapidly in the DO condition (correlated outcomes) relative to the NDO condition (common outcome).

Differential outcomes should be researched in depth. If the DOE can provide another way for behavior analysis increase the efficiency of socially relevant and meaningful change in the lives of the individuals we serve, we should be doing what we can to chase down all the answers. The potential clinical utility of differential outcomes is immense, and increasing the rate of skill acquisition in children with ASD could provide another tool that behavior analysts can use to minimize deficits and increase skill acquisition.

The robustness and reliability of the DOE in experimental arrangements with nonhuman subjects makes the phenomenon a compelling research topic for applied behavior analysis. Procedures that produce the increase in rates of acquisition that differential outcomes procedures have shown should be examined for use in clinical settings. Any strategy that may increase the chances of closing the gap in the learning rate between children with Autism Spectrum Disorders (ASD) and their typically developing peers is of extreme value and the field should be dedicating effort towards further evaluating its utility.

Table 1

Targets and Outcomes for Sally

Set	Target	Preferred Item (DO)	Preferred Item (NDO)
A	Hippo	Barbie	
	Otter	Toy Phone	
	Moose	Train Book	
B	Camel	ABC Toy	Popup Toy
	Rhino	Toy Horse	
	Fox	Toy Train	
C	Kangaroo	Treehouse Toy	
	Crab	See n' Say	
	Chipmunk	Minnie Puzzle	
D	Deer	Alien Toys	Peppa Pig Book
	Goose	Toy Airplane	
	Dolphin	Sesame Street Toy	

Table 2

Targets and Outcomes for Jack

Set	Target	Preferred Item (DO)	Preferred Item (NDO)
A	Blocks	Cat in the Hat Book	
	Shapes	Toy Pig	
	Pencils	Sofia the 1st Puzzle	
B	People	Woody	Firetruck Toy
	Animals	Legos	
	Clothing	Toy Camera	

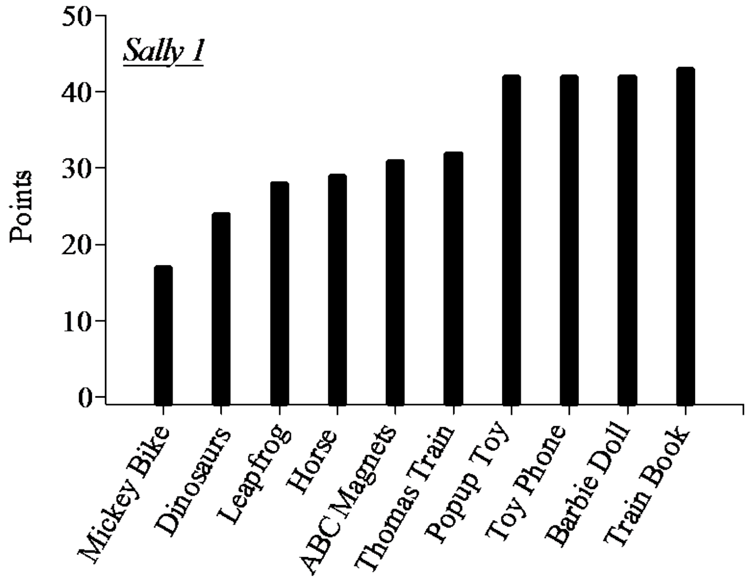

Figure 1. Results of the first MSWO preference assessment run with Sally. The top four items were selected for use as the initial outcomes during teaching. The next three items were used when Set B was changed from NDO to DO procedures.

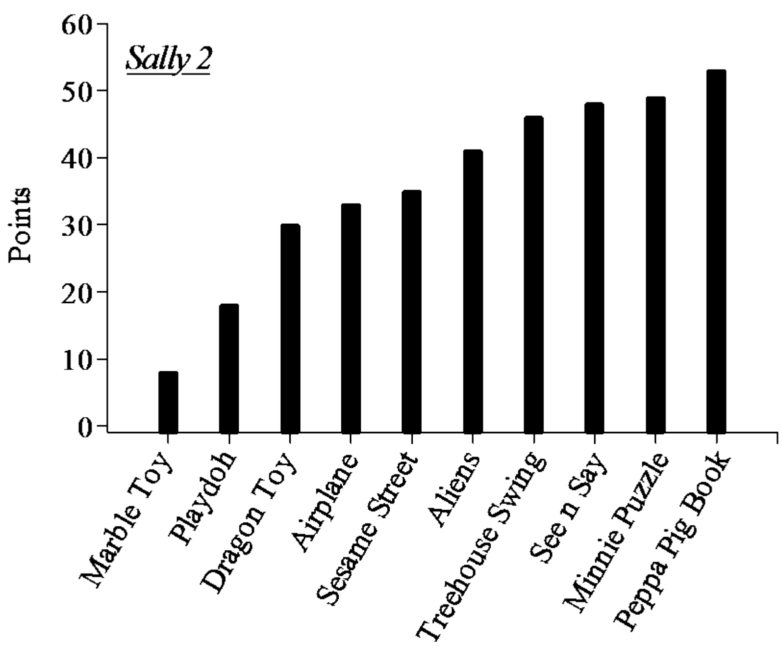

Figure 2. Results of the second MSWO preference assessment run with Sally. The top four items were selected for use as the initial outcomes during teaching. The next three items were used when Set D was changed from NDO to DO procedures.

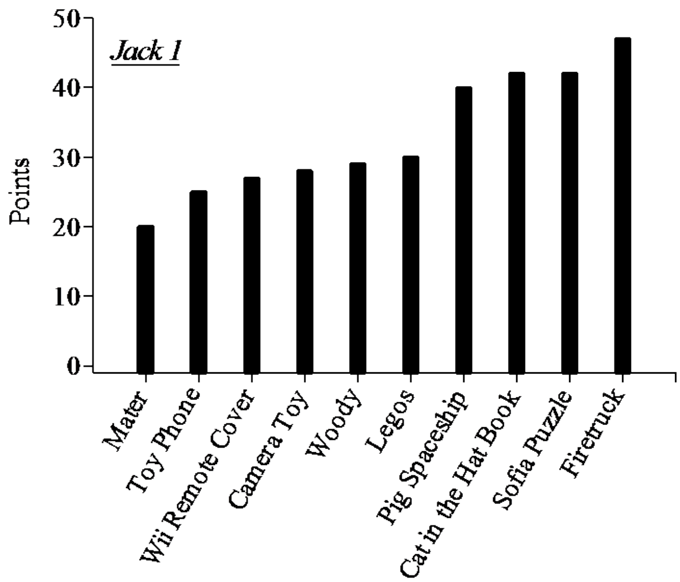

Figure 3. Results of the first MSWO preference assessment run with Jack. The top four items were selected for use as the initial outcomes during teaching. The next three items were used when Set B was changed from NDO to DO procedures.

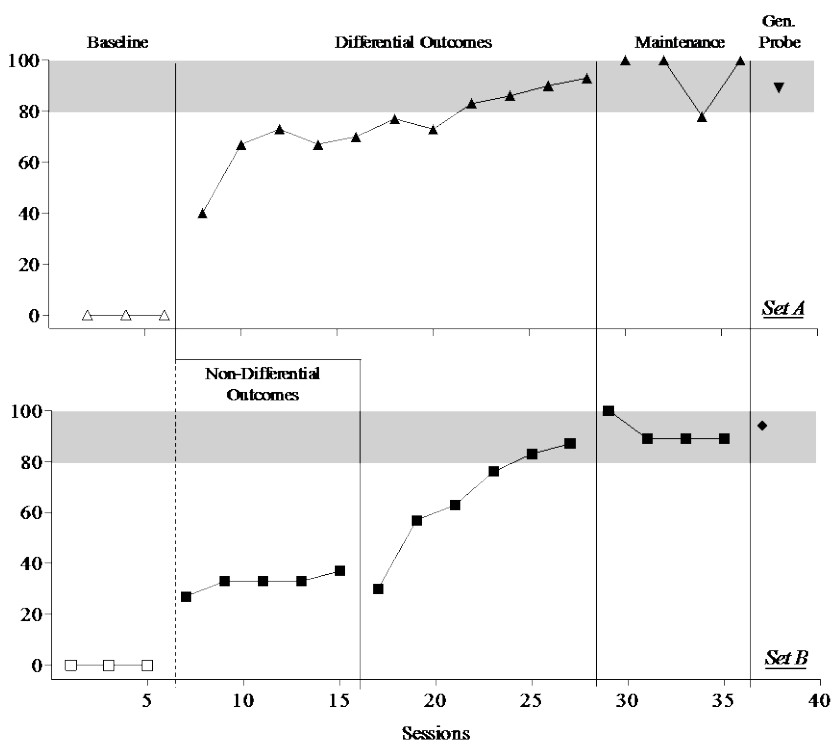

Figure 4. Differentiation is seen between DO and NDO conditions. Immediate increase in accuracy is seen in Set B when DO procedures are used. Both Set A and B maintained at high levels, and Sally performed with high accuracy with generality probes.

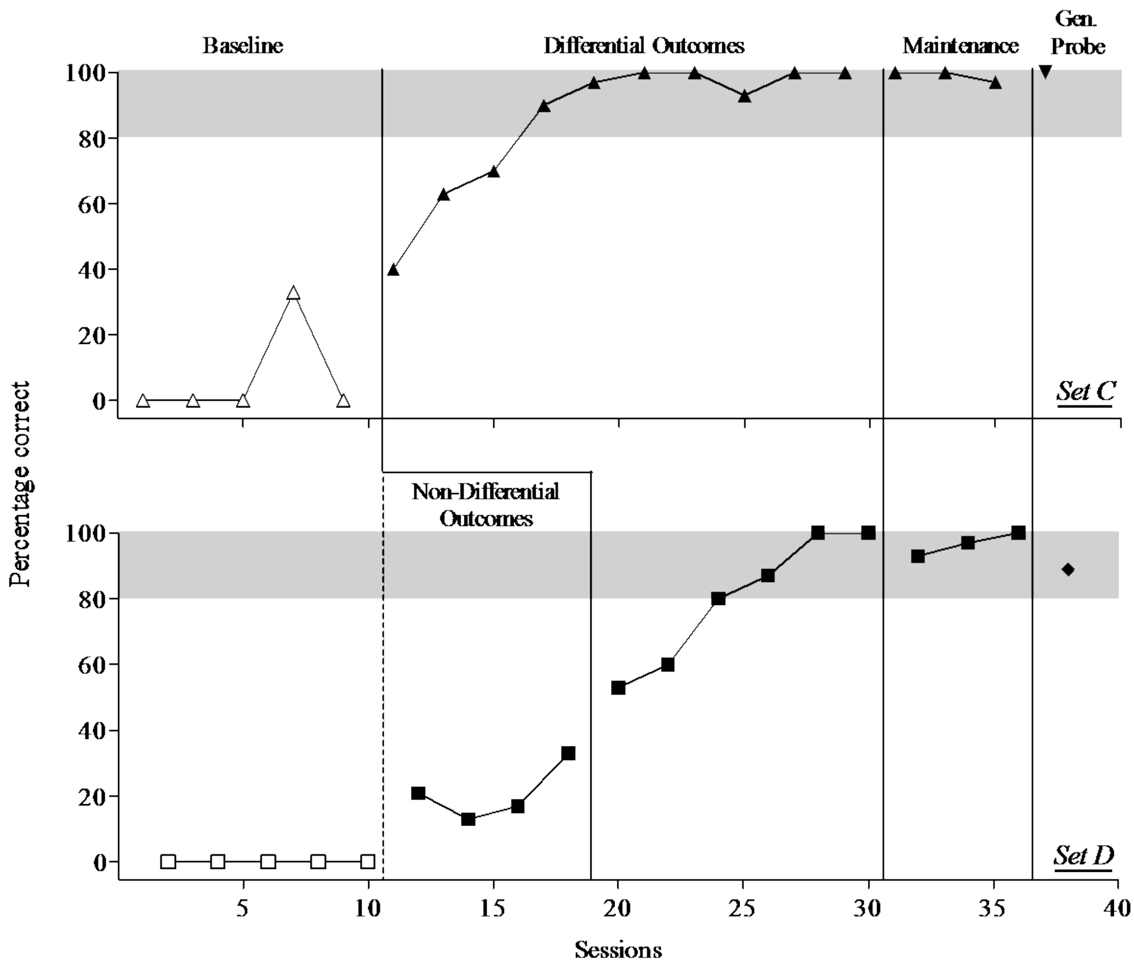

Figure 5. Differentiation is seen between DO and NDO conditions. Immediate increase in accuracy is seen in Set B when DO procedures are used. Both Set C and D maintained at high levels, and Sally performed with high accuracy during generality probes.

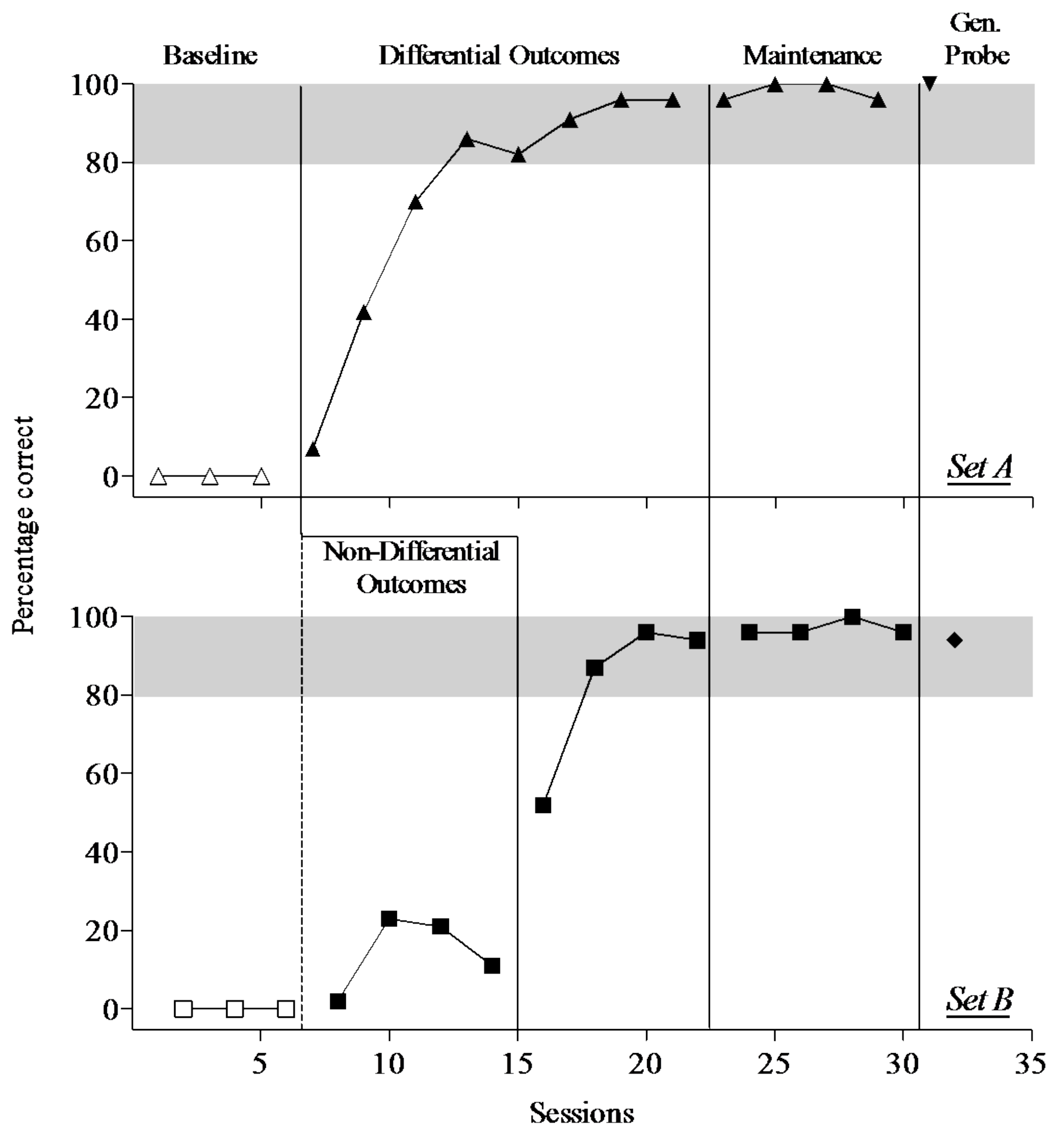

Figure 6. Significant differentiation is seen between DO and NDO conditions. Immediate increase in accuracy is seen in Set B when DO procedures are used, and mastery is achieved within four sessions. Both sets maintained at high levels, and Jack performed with high accuracy during generality probes.

REFERENCES

Alling, K., Nickel, M., & Poling, A. (1991a). The effects of differential and nondifferential outcomes on response rates and accuracy under a delayed-matching-to-sample procedure. *Psychological Record*, *41*, 537-549.

Alling, K., Nickel, M., & Poling, A. (1991b). The effects of phenobarbital on responding under delayed-matching-to-sample procedures with differential and nondifferential outcomes. *Pharmacology, Biochemistry, & Behavior*, *39*, 817-820.

Carlson, J. G., & Wielklewicz, R. M. (1972). Delay of reinforcement in instrumental discrimination learning of rats. Journal of Comparative & Physiological Psychology, 81, 365-370.

Carlson, J. G., & Wielklewicz, R. M. (1976). Mediators of the effects of magnitude of reinforcement. Learning & Motivation, 7, 184-196.

Charlop, M. H., Schreibman, L., & Thibodeau, M. G. (1985). Increasing spontaneous verbal responding in autustic children using a time delay procedure. *Journal of Applied Behavior Analysis*, *18*(2), 155-166.

Chong, I. M, & Carr, J.E. (2010). Failure to demonstrate the differential outcomes effect in children with autism. *Behavioral Interventions, 25,* 339-348.

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis*, *29*(4), 519-533.

Demarse, T., & Urcuioli, P. J. (1993). Enhancement of matching acquisition by differential comparison-outcome associations. *Journal of Experimental Psychology: Animal Behavior Processes,* 19, 317- 326.

Estévez, A. F., Fuentes, L. J., Marı-Bêffa, P., González, C., & Alvarez, D. (2001). The differential outcome effect as a useful tool to improve conditional discrimination learning in children. Learning and Motivation, 32(1), 48-64.

Fedorchak, P. M., & Bolles, R. C. (1986). Differential outcome effect using a biologically neutral outcome difference. Journal of Experimental Psychology: Animal Behavior Processes, *12*, 125-130.

Friedman, G. J., & Carlson, J. G. (1973). Effects of a stimulus correlated with positive reinforcement upon discrimination learning. Journal of Experimental Psychology, *97*, 281-286.

Friedrich, A. M., & Zentall, T. R. (2011). A differential-outcome effect in pigeons using spatial hedonically nondifferential outcomes. *Learning & Behavior, 39*(1), 68-78.

Kelly, R., & Grant, D. S. (2001). A differential outcomes effect using biologically neutral outcomes in delayed matching-to-sample with pigeons. *The Quarterly Journal of Experimental Psychology*, *54*(1), 69-79.

Litt, M. D., & Schreibman, L. (1981). Stimulus-specific reinforcement in the acquisition of receptive labels by autistic children. Analysis and Intervention in Developmental Disabilities, 1, 171–186.

Malanga, P., & Poling, A. (1992). Letter recognition by adults with mental handicaps: Improving performance through differential outcomes. Developmental Disabilities Bulletin, 20, 39–48.

McCormack, J., Arnold-Saritepe, A., & Elliffe, D. (2017). The differential outcomes effect in children with autism. *Behavioral Interventions, 32*(4), 357-369.

Miller, H. C., Friedrich, A. M., Narkavic, R. J., & Zentall, T. R. (2009). A differential-outcomes effect using hedonically nondifferential outcomes with delayed matching to sample by pigeons. *Learning & Behavior, 37*(2), 161-166.

Miyashita, Y., Nakajima, S., & Imada, H. (2000). Differential outcome effect in the horse. *Journal of the Experimental Analysis of Behavior*, *74*, 245-253.

Morgan, T. B., & Baker, L. E. (1997). The application of differential outcomes to a cocaine–saline discrimination procedure. *Behavioural Pharmacology*, *8*, 31-36.

Nakajima, S., & Kobayashi, H. (2000). Differential outcomes effect on instrumental serial feature-ambiguous discrimination in rats. Psychological Record, *50*, 189-198.

Overmier, J. B., Bull, J. A., III, & Trapold, M. A. (1971). Discriminative cue properties of different fears and their role in response selection in dogs. Journal of Comparative & Physiological Psychology, *76*, 478-482.

Trapold, M. A. (1970). Are expectancies based upon different positive reinforcing events discriminably different? *Learning & Motivation*, *1*, 129-140.

Sherburne, L. M., & Zentall, T. R. (1998). The differential outcomes effect in pigeons is not reduced by eliminating response-outcome associations: Support for a two-process account. *Animal Learning & Behavior, 26*(4), 378-387.

Shepp, B. E. (1962). Some cue properties of anticipated rewards in discrimination learning of retardates. *Journal of Comparative and Physiological Psychology, 55*(5), 856-859.

Shepp, B. (1964). Some Cue Properties of Rewards in Simultaneous Object-Discriminations of Retardates. *Child Development, 35*(2), 587-592.

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston: Authors Cooperative.

Sidman, M. (2000). Equivalence relations and the reinforcement contingency. *Journal of the Experimental Analysis of Behavior*, *74*, 127–146.

Sindelar, P. T., Rosenberg, M. S., & Wilson, R. J. (1985). An adapted alternating treatments design for instructional research. *Education and Treatment of Children, 8*(1), 67-76.

Urcuioli, P. J. (2005). Behavioral and associative effects of differential outcomes in discrimination learning. Learning and Behavior, *33*, 1–21.

Urcuioli, P. J. (1991). Retardation and facilitation of matching acquisition by differential outcomes. *Animal Learning & Behavior*, *19*, 29-36.

Urcuioli, P. J. (1990). Some relationships between outcome expectancies and sample stimuli in pigeons' delayed matching. *Animal Learning* & *Behavior,* 18, 302-314.

Urcuioli, P. J., & DeMarse, T. B. (1996). Associative processes in differential outcome discriminations. *Journal of Experimental Psychology: Animal Behavior Processes*, *22*, 192-204.

Urcuioli, P. J., & Zentall, T. R. (1992). Transfer across delayed discriminations: Evidence regarding the nature of prospective working memory. *Journal of Experimental Psychology: Animal Behavior Processes*, *18*, 154-173.

Zentall, T. R., & Sherburne, L. M. (1994). Role of differential sample responding in the differential outcomes effects involving delayed matching by pigeons. *Journal of Experimental Psychology: Animal Behavior Processes*, *20*, 390-401.